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1 49. (Currently Amended) A cross-linking compound which comprises:

2 (a) an anhydrous hydrocarbon compound liquid at ambient temperature having elemental
3 sulfur, oxygen or selenium therein, wherein said hydrocarbon compound is Di-tert-butyl polysulfide,
4 Di-tert-dodecyl polysulfide, Di-tert-nonyl polysulfide or combinations thereof; and

5 (b) an ethylenic polymer liquid at ambient temperature having a molecular weight
6 less than 25,000 ~~30,000~~, wherein said polymer is a copolymer of butylene and butene.

1 50. (Original) A cross-linking compound as set forth in Claim 1 wherein said anhydrous
2 hydrocarbon compound is an organic process oil from crude or coal processing.

1 51. (Original) A cross-linking compound as set forth in Claim 12 wherein said anhydrous
2 hydrocarbon compound is an organic process oil from crude or coal processing.--

REMARKS

The Office Action of April 16, 2004 has been fully considered by the Applicant. Based on Applicant's prior amendment, the Examiner has withdrawn the Section 102 rejection. Instead, the Examiner has rejected the pending claims as obvious under 35 U.S.C. §103(a) as unpatentable over Hagenbach et al., Patent Number 4,567,222.

The Examiner acknowledges that a limitation of the polymer in claim 1, lines 5-6 is no longer overlapping with Hagenbach. Specifically, Hagenbach et al., discloses that the average molecular weight of the copolymer, "may be advantageously comprised between 30,000 and 300,000 and

located preferably between 70,000 and 200,000" see column 4, lines 45-50. MPEP §2144.05

discusses overlapping of ranges (copy attached hereto). In particular, §2144.05 states as follows:

In the case where the claimed ranges "overlap or lie inside ranges disclosed in the prior art" a *prima facie* case of obviousness exists. "In *re Wertheim*, 541 F.2d 257, 191 USPQ 90 (CCPA 1976); In *re Woodruff*, 919 F.2d 1575, 16 USPQ2d 1934 (Fed. Cir. 1990) (The prior art taught carbon monoxide concentrations of "about 1-5%" while the claim was limited to "more than 5%." The court held that "about 1-5%" allowed for concentrations slightly above 5% thus the ranges overlapped.); In *re Geisler*, 116 F.3d 1465, 1469-71, 43 USPQ2d 1362, 1365-66 (Fed. Cir. 1997) (Claim reciting thickness of a protective layer as falling within a range of "50 to 100 Angstroms" considered *prima facie* obvious in view of prior art reference teaching that "for suitable protection, the thickness of the protective layer should be not less than about 10 nm [i.e., 100 Angstroms]." The court stated that "by stating that 'suitable protection' is provided if the protective layer is 'about' 100 Angstroms thick, [the prior art reference] directly teaches the use of a thickness within [applicant's] claimed range."). Similarly, a *prima facie* case of obviousness exists where the claimed ranges and prior art ranges do not overlap but are close enough that one skilled in the art would have expected them to have the same properties. *Titanium Metals Corp. of America v. Banner*, 778 F.2d 775, 227 USPQ 773 (Fed. Cir. 1985) (Court held as proper a rejection of a claim directed to an alloy of "having 0.8% nickel, 0.3% molybdenum, up to 0.1% iron, balance titanium" as obvious over a reference disclosing alloys of 0.75% nickel, 0.25% molybdenum, balance titanium and 0.94% nickel, 0.31% molybdenum, balance titanium.).

In the present case, the claims do not overlap with the prior art ranges. The example cited in the MPEP for obviousness differs dramatically from the present case. In the cited case of Titanium Metals, the claim was directed to an alloy which was between two prior art references which bracketed the claimed percentage. In other words, a claim for .8% nickel was rejected based on a prior reference for .94% nickel and a prior reference for .75% nickel.

This is to be contrasted with the present case wherein the prior art ranges are at the broadest between 30,000 and 300,000 and are preferably in a reduced range of 70,000 and 200,000.

Introduction to Polymer Chemistry, by Raymond B. Seymour, McGraw-Hill, Inc., 1971, p. 53, Fig. 3-1, shows in simple chart form the effect of molecular weight on three polymer properties.

This chart illustrates to one of average skill in the art the importance of molecular weight. Therefore, one of average skill in the art would be lead to believe the art taught in Pat. No. 4,567,222 would not consider polymers outside 30,000 to 300,000 molecular weights. Applicant teaches new and novel use of polymers below 30,000 molecular weight.

Moreover, MPEP §2144.05 confirms that even a *prima facie* case of obviousness, “may also be rebutted by showing that the art, in any material respect, teaches away from the claimed invention.” In re Geisler, 116 F.3d 1465, 1471, 43 USPQ2d 1362, 1366 (Fed. Cir. 1997). By disclosing an outside range of 30,000 to 300,000 and a preferred range of 70,000 to 200,000, Hagenbach teaches away from a lower range.

In any event, Applicant’s present amendment clarifies that its claims are significantly different and nonobvious from Hagenbach et al.or other references.

Additionally, Hagenbach et al. differs from the present invention in that it does not include the limitation of claim 1, line 5 of a polymer “liquid at ambient temperature.” In Hagenbach et al., a solid polymer is contemplated and is disclosed. In each example in Hagenbach, a solvent in the form of a hydrocarbon oil is required to solvate the solid polymer into a liquid in the form of a mother solution. This is specifically described in example 2 of Hagenbach et al., Column 7 wherein a powder of the copolymer is specifically called for (in other words, solid). The present invention is directed to a polymer which is, “liquid at ambient temperature,” and does not require a solvent mother solution step or process in order to utilize. The present invention is also consistent with the lower molecular weight polymer which is constituted as a liquid rather than the teaching of Hagenbach of a higher molecular weight polymer being a solid.

For all the foregoing reasons, it is believed that application is now in condition for allowance and such action is urgently solicited. If any issues remain, a telephone conference with the Examiner is respectfully requested.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Mark G. Kachigian', written over a horizontal line.

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C. Rearrangement of Parts

In re Japikse, 181 F.2d 1019, 86 USPQ 70 (CCPA 1950) (Claims to a hydraulic power press which read on the prior art except with regard to the position of the starting switch were held unpatentable because shifting the position of the starting switch would not have modified the operation of the device.); *In re Kuhle*, 526 F.2d 553, 188 USPQ 7 (CCPA 1975) (the particular placement of a contact in a conductivity measuring device was held to be an obvious matter of design choice). However, "The mere fact that a worker in the art could rearrange the parts of the reference device to meet the terms of the claims on appeal is not by itself sufficient to support a finding of obviousness. The prior art must provide a motivation or reason for the worker in the art, without the benefit of appellant's specification, to make the necessary changes in the reference device." *Ex parte Chicago Rawhide Mfg. Co.*, 223 USPQ 351, 353 (Bd. Pat. App. & Inter. 1984).

VII. PURIFYING AN OLD PRODUCT

Pure materials are novel vis-a-vis less pure or impure materials because there is a difference between pure and impure materials. Therefore, the issue is whether claims to a pure material are unobvious over the prior art. *In re Bergstrom*, 427 F.2d 1394, 166 USPQ 256 (CCPA 1970). Purer forms of known products may be patentable, but the mere purity of a product, by itself, does not render the product unobvious. *Ex parte Gray*, 10 USPQ2d 1922 (Bd. Pat. App. & Inter. 1989).

Factors to be considered in determining whether a purified form of an old product is obvious over the prior art include whether the claimed chemical compound or composition has the same utility as closely related materials in the prior art, and whether the prior art suggests the particular form or structure of the claimed material or suitable methods of obtaining that form or structure. *In re Cofer*, 354 F.2d 664, 148 USPQ 268 (CCPA 1966) (Claims to the free-flowing crystalline form of a compound were held unobvious over references disclosing the viscous liquid form of the same compound because the prior art of record did not suggest the claimed compound in crystalline form or how to obtain such crystals.).

See also *Ex parte Stern*, 13 USPQ2d 1379 (Bd. Pat. App. & Inter. 1987) (Claims to interleukin 2 (a protein with a molecular weight of over 12,000) purified to homogeneity were held unpatentable over references which recognized the desirability of purifying interleukin 2 to homogeneity in a view of a reference which taught a method of purifying proteins having molecular weights in excess of 12,000 to homogeneity wherein the prior art method was similar to the method disclosed by appellant for purifying interleukin 2.).

Compare *Ex parte Gray*, 10 USPQ2d 1922 (Bd. Pat. App. & Inter. 1989) (Claims were directed to human nerve growth factor b-NGF free from other proteins of human origin, and the specification disclosed making the claimed factor through the use of recombinant DNA technology. The claims were rejected as *prima facie* obvious in view of two references disclosing b-NGF isolated from human placental tissue. The Board applied case law pertinent to product-by-process claims, reasoning that the prior art factor appeared to differ from the claimed factor only in the method of obtaining the factor. The Board held that the burden of persuasion was on appellant to show that the claimed product exhibited unexpected properties compared with that of the prior art. The Board further noted that "no objective evidence has been provided establishing that no method was known to those skilled in this field whereby the claimed material might have been synthesized." 10 USPQ2d at 1926.).

2144.05 Obviousness of Ranges

See MPEP § 2131.03 for case law pertaining to rejections based on the anticipation of ranges under 35 U.S.C. 102 and 35 U.S.C. 102/103.

I. OVERLAP OF RANGES

In the case where the claimed ranges "overlap or lie inside ranges disclosed by the prior art" a *prima facie* case of obviousness exists. *In re Wertheim*, 541 F.2d 257, 191 USPQ 90 (CCPA 1976); *In re Woodruff*, 919 F.2d 1575, 16 USPQ2d 1934 (Fed. Cir. 1990) (The prior art taught carbon monoxide concentrations of "about 1-5%" while the claim was limited to "more than 5%." The court held that "about 1-5%" allowed for concentrations slightly above 5% thus the ranges overlapped.); *In re Geisler*, 116 F.3d 1465, 1469-71, 43 USPQ2d 1362, 1365-66 (Fed. Cir. 1997) (Claim reciting thickness of a protective layer as falling within a range of "50 to 100 Angstroms" considered *prima facie* obvious in view of prior art reference teaching that "for suitable protection, the thickness of the protective layer should be not less than about 10 nm [i.e., 100 Angstroms].") The court stated that "by stating that 'suitable protection' is provided if the protective layer is 'about' 100 Angstroms thick, [the prior art reference] directly teaches the use of a thickness within [applicant's] claimed range."). Similarly, a *prima facie* case of obviousness exists where the claimed ranges and prior art ranges do not overlap but are close enough that one skilled in the art would have expected them to have the same properties. *Titanium Metals Corp. of America v. Banner*, 778 F.2d 775, 227 USPQ 773 (Fed. Cir. 1985) (Court held as proper a rejection of a claim directed to an alloy of "having 0.8% nickel, 0.3% molybdenum, up to 0.1% iron, balance titanium" as obvious over a reference

disclosing alloys of 0.75% nickel, 0.25% molybdenum, balance titanium and 0.94% nickel, 0.31% molybdenum, balance titanium.).

art suggested proportional balancing to achieve desired results in the formation of an alloy).

II. OPTIMIZATION OF RANGES

A. Optimization Within Prior Art Conditions or Through Routine Experimentation

Generally, differences in concentration or temperature will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such concentration or temperature is critical. "[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." *In re Aller*, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955) (Claimed process which was performed at a temperature between 40C and 80C and an acid concentration between 25 and 70% was held to be *prima facie* obvious over a reference process which differed from the claims only in that the reference process was performed at a temperature of 100C and an acid concentration of 10%). See also *In re Hoeschele*, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969) (Claimed elastomeric polyurethanes which fell within the broad scope of the references were held to be unpatentable thereover because, among other reasons, there was no evidence of the criticality of the claimed ranges of molecular weight or molar proportions.). For more recent cases applying this principle, see *Merck & Co. Inc. v. Biocrast Laboratories Inc.*, 874 F.2d 804, 10 USPQ2d 1843 (Fed. Cir.), *cert. denied*, 493 U.S. 975 (1989); *In re Kulling*, 897 F.2d 1147, 14 USPQ2d 1056 (Fed. Cir. 1990); and *In re Geisler*, 116 F.3d 1465, 43 USPQ2d 1362 (Fed. Cir. 1997).

B. Only Result-effective Variables Can Be Optimized

A particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977) (The claimed wastewater treatment device had a tank volume to contractor area of 0.12 gal./sq. ft. The prior art did not recognize that treatment capacity is a function of the tank volume to contractor ratio, and therefore the parameter optimized was not recognized in the art to be a result-effective variable.). See also *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980) (prior

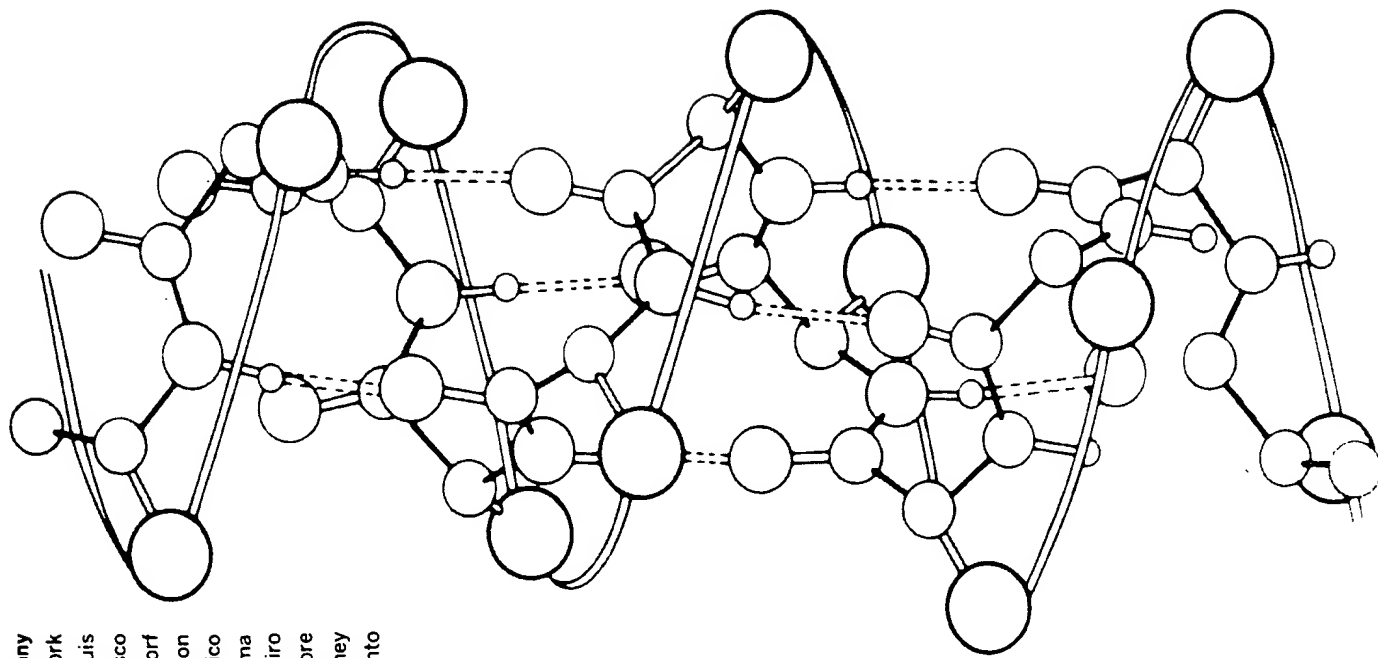
III. REBUTTAL OF PRIMA FACIE CASE OF OBVIOUSNESS

Applicants can rebut a *prima facie* case of obviousness based on overlapping ranges by showing the criticality of the claimed range. "The law is replete with cases in which the difference between the claimed invention and the prior art is some range or other variable within the claims. . . . In such a situation, the applicant must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range." *In re Woodruff*, 919 F.2d 1575, 16 USPQ2d 1934 (Fed. Cir. 1990). See MPEP § 716.02 - § 716.02(g) for a discussion of criticality and unexpected results.

A *prima facie* case of obviousness may also be rebutted by showing that the art, in any material respect, teaches away from the claimed invention. *In re Geisler*, 116 F.3d 1465, 43 USPQ2d 1362, 1366 (Fed. Cir. 1997) (Applicant argued that the prior art taught away from use of a protective layer for a reflective article having a thickness within the claimed range of "50 to 100 Angstroms." Specifically, a patent to Zehender, which was relied upon to reject applicant's claim, included a statement that the thickness of the protective layer "should be not less than about [100 Angstroms]." The court held that the patent did not teach away from the claimed invention. "Zehender suggests that there are benefits to be derived from keeping the protective layer as thin as possible, consistent with achieving adequate protection. A thinner coating reduces light absorption and minimizes manufacturing time and expense. Thus, while Zehender expresses a preference for a thicker protective layer of 200-300 Angstroms, at the same time it provides the motivation for one of ordinary skill in the art to focus on thickness levels at the bottom of Zehender's 'suitable' range- about 100 Angstroms- and to explore thickness levels below that range. The statement in Zehender that '[i]n general, the thickness of the protective layer should be not less than about [100 Angstroms]' falls far short of the kind of teaching that would discourage one of skill in the art from fabricating a protective layer of 100 Angstroms or less. [W]e are therefore 'not convinced that there was a sufficient teaching away in the art to overcome [the] strong case of obviousness' made out by Zehender."). See MPEP § 2145, paragraph X.D., for a discussion of "teaching away" references.

Introduction to Polymer Chemistry

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Introduction to Polymer Chemistry

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Preface

This treatise was written for use as a two-semester undergraduate textbook for senior students majoring in chemistry or chemical engineering. A prior knowledge of organic chemistry is a prerequisite but no previous knowledge of polymer science is required for an understanding of this textbook. In manuscript form, this book was classroom-tested in undergraduate courses for four successive years. It has also been used for an equivalent period for leveling work in graduate courses in polymer science.

Over one hundred industrial scientists and technologists from over a score of different companies have taken courses in which this manuscript served as the textbook. A larger number of industrial chemists who had had no formal training in polymer science have also found the manuscript to be a valuable reference. It is hoped that the book will also be helpful to those who have not had the opportunity of taking a formal course as well as to students in polymer chemistry.

The subject matter has been arranged so that the book may also be used in a one-quarter or one-semester course. Some chapters, such as those on natural products, inorganic polymers, processing, testing, and technology, may be omitted if sufficient time is not available. The last chapter and sections of "Modern Plastics Encyclopedia" may be assigned as outside reading. When time is available, it is also advisable to assign some of the reference material following sections of this book and to direct the students' attention to current literature in the polymer field.

A course in polymer science is essential for the many students who will find employment in this field. Because polymer science is interdisciplinary in nature, those students who may go into other fields will find

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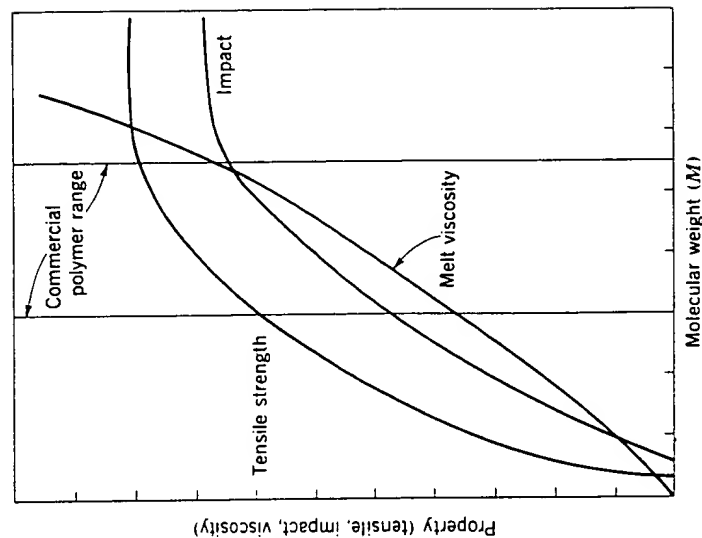


Fig. 3-1 Relationship of polymer properties to molecular weight.

A threshold molecular weight is essential for attainment of the unique properties that characterize high polymers. As indicated in Fig. 3-2, the softening temperature of low-molecular-weight polyethylene is a function of the degree of polymerization (DP). Thus, dimers and trimers of ethylene are gases. Oligomers with a DP of 4 or more are liquid.

The viscosities of these liquids increase as the chain lengths increase. Polyethylenes with DP's of about 30 are greaselike. Those polymers with DP's around 50 resemble paraffin wax and become harder as the DP increases. Polyethylenes with DP's greater than 400 are hard resins with softening points above 100°C. The number of carbon atoms in the polymer backbone and intermolecular forces must also be considered when polymers with similar DP's are compared. Thus poly(hexamethylene adipamide) (nylon 6,6) with a DP in the 50 to 100 range is more rigid than the polyethylene with a comparable DP because of the increased strength associated with the higher intermolecular attractive forces. Polymers with DP's in the 500 to 1,000 range are more useful for commercial fibers. The DP values for most amorphous plastics and elastomers are usually above 1,000.

3 Molecular Weights of Polymers

Pure low-molecular-weight organic compounds, such as sucrose, and some polymers, such as proteins, are *monodisperse*; i.e., all the molecules in any sample of pure material have identical molecular weight (M). In contrast, *polydispersity* is a characteristic of most macromolecules. The range of different molecular weights of the molecules in a sample may be narrowed by fractionation but monodisperse systems are seldom encountered in synthetic polymer systems. Hence, the polymer scientist is usually concerned with an average molecular weight (\bar{M}).

In general, properties such as density, refractive index, and hardness of high polymers are essentially independent of molecular weight. However, properties of amorphous polymers, such as melt viscosity, softening temperature, tensile and impact strengths, and heat resistance, are related to the length of the polymer chain.

As shown in Fig. 3-1, tensile- and impact-strength properties increase rapidly as the chain length increases and then level off. Thus a range of usefulness or commercial range has been established in which the polymer chain is of sufficient length, i.e., above the *threshold value*, to provide minimum useful properties. The melt viscosity continues to increase rapidly as the molecular weight increases above the threshold value. Since polymers with very high molecular weights are difficult to process and fabricate, an appropriate compromise is usually made between maximum physical properties and processibility. It should be noted that physical properties are also related to the degree of polydispersity.

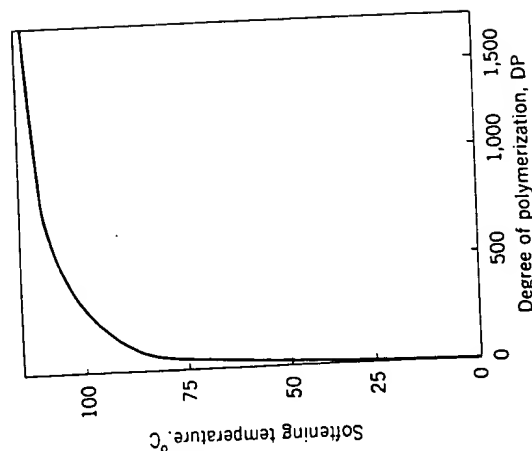


Fig. 3.2 Relationship of softening temperature and degree of polymerization for polyethylene.

The pioneering discoveries of Raoult and van't Hoff provided techniques which are extremely useful for the determination of the molecular weights of small molecules, such as sucrose. Unprecedented high values were obtained when early investigators used techniques such as osmometry for measuring the molecular weights of natural products. However, the significance of the data was not recognized. Hence, the early experiments proposed aggregates of molecules rather than long polymeric chains.

In spite of a clearer understanding of polymer structure demonstrated later by Staudinger, Meyer, Mark, Carothers, Guth, and Kuhn, erroneous interpretations of polymer structure and chain length were prevalent in the early 1930s. The study of polymer structure by the more enlightened pioneers was complicated by polydispersity and intermolecular attractions between polymer molecules in solution. Progress was made by Staudinger in the determination of molecular weights from viscosity measurements. Unfortunately, the effect of solvents on the shape of the dissolved polymer molecules was not recognized at that time.

Staudinger's values were based on the erroneous assumption that the intrinsic viscosity $[\eta]$ was directly proportional to the molecular weight. Thus, although his molecular-weight values were higher than the unextrapolated values obtained by measurement of colligative properties, they were considerably smaller than those now accepted as correct. The viscosity method and the many other indirect and direct techniques for the determination of molecular weights will be discussed in this chapter.

3-1 VISCOSITY

As explained under the subject of rheology in Sec. 2-1, the intrinsic viscosity is the intercept obtained by extrapolating the straight line obtained when η_{sp}/C is plotted against C . The specific viscosity η_{sp} may be obtained from simple measurements of the time of flow of the solvent (t') and of the solution (t) in a capillary viscometer such as an Ubbelohde viscometer. Thus

$$\eta_{sp} = \frac{t}{t'} - 1 \quad (3-1)$$

Viscosity-flow-time equation

The time of flow for a liquid between a fixed mark in a capillary viscometer at constant temperature is related to Poiseuille's equation for streamline flow. Provided values for the constants are known and the relationships are linear, the average molecular weight may be calculated from the Mark-Houwink equation.

3-2 NUMBER AVERAGE MOLECULAR WEIGHT

The average-molecular-weight values (\bar{M}_n) obtained by viscosity techniques are between the number average \bar{M}_n and weight average \bar{M}_w and closer to the latter. When the values for the exponent A in the Mark-Houwink equation are less than 0.7, \bar{M}_w and \bar{M}_n are similar.

The number average \bar{M}_n or arithmetic mean may be obtained by actually counting the molecules. The molecules may be counted by end-group analysis, tagged atoms, or chromophoric groups. Similar values are obtained by indirect counting, i.e., measuring the effect of the molecules on colligative properties, viz., osmometry, cryoscopy, and ebullioscopy.

The number average molecular weight \bar{M}_n assumes that each molecule makes an equal contribution to polymer properties regardless of size or weight. Facetiously, this is equivalent to saying that hash made from one horse and four chickens is 80 percent chicken hash. However, the number average values \bar{M}_n are obtained by similar reasoning.

Thus the number average \bar{M}_n for three macromolecules with individual molecular-weight values of 150,000; 200,000; and 250,000 is $(600 \times 10^3)/3 = 200 \times 10^3$. The number average is a good index of physical properties such as impact and tensile strength but is not a good index of other properties

such as flow. In the kinetics of polymerization, which will be discussed subsequently, one must know the number of molecules present; hence \bar{M}_n is essential for kinetic studies.

3-3 WEIGHT AVERAGE MOLECULAR WEIGHT

Light scattering and sedimentation equilibrium (ultracentrifugation) techniques, which measure molecular size, yield weight average molecular weight (\bar{M}_w) data. These values, in which each molecule contributes in accordance with its weight, are obtained by dividing the summation of the square of the molecular-weight values by the summation of the molecular weights of all the molecules present.

Thus the hash that was called 80 percent by the number-average approach would be shown to be essentially horse hash with a trace of chicken by the weight-average approach. The weight average \bar{M}_w for the three macromolecules with molecular weights of 150,000; 200,000; and 250,000 would be equal to $[(150)^2 + (200)^2 + (250)^2] \times 10^6 / (600 \times 10^3) = 208 \times 10^3$.

The weight average \bar{M}_w is always greater than the number average \bar{M}_n for polydisperse systems. Since $\bar{M}_w = \bar{M}_n$ in monodisperse systems, the ratio \bar{M}_w/\bar{M}_n or $(\bar{M}_w/\bar{M}_n) - 1$ may be used as a measure of the molecular-weight distribution or as an index of polydispersity.

The z-average molecular weight \bar{M}_z obtainable from measurements of the radial distribution of the refractive-index gradient in sedimentation equilibrium is greater than the weight average \bar{M}_w . Thus, as shown in Fig. 3-3, the distribution of molecular weights for typical nonhomogeneous polydisperse systems is as follows: $\bar{M}_z > \bar{M}_w > \bar{M}_v > \bar{M}_n$.

3-4 FRACTIONATION OF POLYMER SYSTEMS

A polydisperse system may be separated into fractions with narrower distribution ranges of molecular weight by cooling, diffusion, solvent volatilization, precipitation, elution or extraction, centrifugation, ultrafiltration through graded sieves, zone melting, and exclusion chromatographic adsorption. The discrete fractions obtained are characterized by appropriate molecular-weight determinations.

Since solubility of members of a homologous series in a specific solvent decreases as the molecular weight increases, the change in solubility parameter of a solvent system may be used for fractionation of discrete molecular-

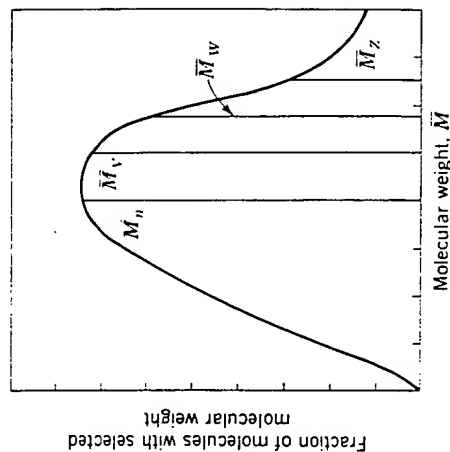


Fig. 3-3 Molecular-weight distribution in a typical polymer.

weight ranges. In this technique, the higher molecular-weight fractions are precipitated preferentially by the addition of a small amount of miscible solvents with different solubility parameters.

This preferred method may be illustrated by the addition of sufficient isopropanol to cause turbidity in a benzene solution of polystyrene at constant temperature. Attainment of equilibrium may be assured by heating the heterogeneous mixture and cooling to the specified temperature. This process is repeated on the filtrate after the precipitate has been removed. Better separations are possible with *refractionation*.

This process may be simplified by the use of precipitation chromatography based on an automatic continuous precipitation and dissolution in a column equipped with an automatic fraction collector. In elution fractionation, the lowest molecular polymers are preferentially extracted from solid polymers which have been distributed on the surface of glass beads in a column.

3-5 OSMOMETRY

Osmometers are available commercially for the determination of molecular weights (\bar{M}_n) of polymers. The Fuoss-Mead osmometer consists of a semipermeable cellulosic membrane held between two grooved circular metal blocks equipped with glass capillaries and supply standpipes. Solvent and solution are added to separate standpipes. Thus the solvent passes through the semipermeable membrane until a specific hydrostatic head is established